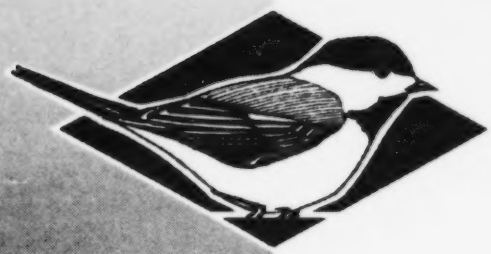
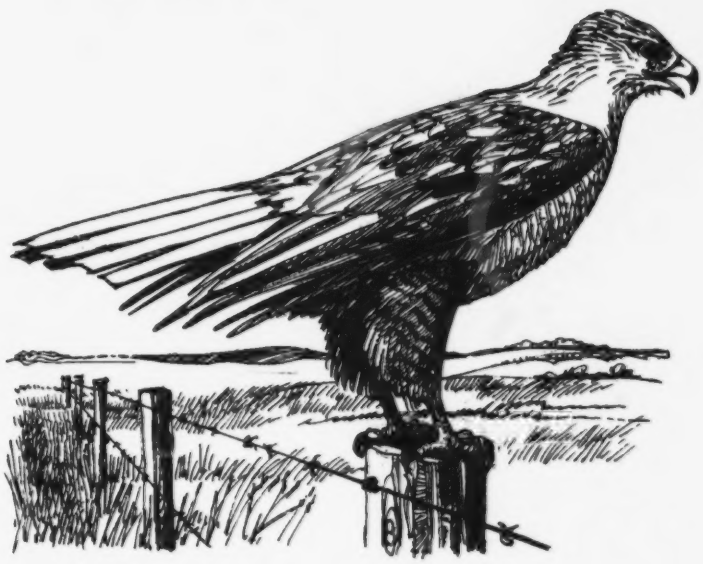


Fish & Wildlife Division

RESOURCE DATA AND SPECIES AT RISK SECTION

The 2005 Ferruginous Hawk Inventory and Population Analysis



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Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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The 2005 Ferruginous Hawk Inventory and Population Analysis

Brandy L. Downey

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EXECUTIVE SUMMARY

The Alberta ferruginous hawk (*Buteo regalis)* inventory was initiated in 1982 to determine the species distribution and abundance in the Grassland Natural Region of Alberta (Schmutz 1982). The survey was repeated in 1987, 1992, and 2000 and a population estimate were extrapolated from the number of active nests found in each year. The past four population estimates have had relatively low precision. Due to this reviews of the survey design were conducted in 2002 and 2005, which recommended several changes be made to increase precision. These included: 1) that the survey quadrats be stratified into two strata, 2) increase the number of quadrats and 3) decrease the size of the study area (Taylor 2003, Saunders 2005). These changes were implemented during the 2005 survey. One hundred and forty seven, 6.4 x 6.4 km^2 quadrats were sampled, 88 in the "high" stratum and 59 in the "low" stratum. A population estimate of 618 +/- 162 pairs of ferruginous hawks was derived. This population estimate is similar to the 2000 estimate but with higher precision; and substantially less than the 1992 population. Trend data collected between 2000-2005 in the Grassland Natural Region, showed a relatively stable population, which indicates that the population has been low since 2000.

The changes recommended for the 2005 surveys were made to alleviate concerns about the statistical precision of the results. These changes substantially increased the confidence in the population estimate. The decline in the number of ferruginous hawks in the province is cause for concern. The ferruginous hawk is currently considered a "Threatened" species in Alberta's Wildlife Act. Based on these 2005 results the ferruginous hawk should be reviewed by the Scientific Subcommittee of the Endangered Species Conservation Committee to re-ascertain the threatened status and explore the need for any status change.

1.0 INTRODUCTION

Species, such as the ferruginous hawk (*Buteo regalis*), which exhibit declining populations, clumped distribution or are spread out over a large geographical area, are especially difficult to determine accurate population estimates for (Taylor 2003). The ferruginous hawk is a "Threatened" species in Alberta and a "Species of Special Concern" in Canada (Endangered Species Conservation Committee 2003, Committee on the Status of Endangered Wildlife in Canada 2004). Inventories for the species were conducted in 1982, 1987, 1992 and 2000 (Schmutz 1982, 1987, 1993, Stepnisky et al. 2002). Varying results between surveys and low precision prompted reviews of the survey methods and analysis in 2003, and 2005 (Taylor 2003, Saunders 2005). Recommendations from these reviews were applied in 2005 with the aim of determining a population estimate with low confidence limits.

2.0 SURVEY BACKGROUND

A ferruginous hawk quadrat survey was designed in 1982. It consisted of 80, 6.4 km x 6.4 km (41 km^2) randomly selected blocks in a 74,686 km^2 area. The original study area was made up of the Grassland Natural Region excluding the northern fescue and foothills fescue subregions. In 1987 and 1992 a 2,615 km^2 area was added north of Oyen to completely represent the major nesting area of the ferruginous hawk in Alberta and new quadrats were selected within that area (Schmutz 1987, 1993). A total of 83 (1987) and 85 (1992) of the 87 quadrats were surveyed. The study area was increased again in 2000 to include the foothills fescue subregion, which is known to contain a small number of ferruginous hawks (Taylor and Iwassa 2000). Seventeen new quadrats were added in the foothills fescue sub region; however these new quadrats were not included in the population estimate completed in 2000 (Stepnisky et al. 2002).

At the end of each survey a population estimate was done using the methods outlined by Schmutz (1982). The population increased between 1982 and 1987, remained relatively stable between 1987 and 1992 and dropped drastically in 2000 (Table 1). However the confidence limits for the population estimates were considered high for all four survey years (Table 1). These large confidence limits resulted in some overlap between population estimates. That led to debate over the precision of the population estimates, survey techniques, and the amount of time between surveys. A review of the survey protocol was conducted in 2003 (Taylor 2003). Several recommendations were made to increase the accuracy of the survey. These included:

1. Increase the number of survey quadrats from 87 to 150.
2. Stratify the quadrats into 2 habitat stratums (< 50% and $\geq$50% native prairie habitat).
3. Conduct a sub portion of surveys annually.
4. Conduct annual Richardson's ground squirrel surveys (the ferruginous hawks main prey source) on a sub portion of quadrats using the method designed by Downey (2003).

Table 1: Ferruginous hawk population estimates for 1982-2000.

Year	Number of Quadrats	Study Area (km^2)	Estimated number of Pairs	95% Confidence Limit	95% Confidence Intervals
1982*	80	74,686	1082	40.5	653-1511
1987*	83	77,947	1791	28.5	1307-2275
1992*	85	77,947	1702	30.6	1181-2223
2000+	86	77,947	731	50.1	364-1097

* Data from Schmutz 1993
+ Data From Stepnisky et al. 2002

In addition to this review, a consultant was hired in 2005 to conduct a full review of the ferruginous hawk program, survey methods, and analyses (Saunders 2005). Changes in quadrat size, quadrat shape and survey time frame were all reviewed in an effort to determine the most effective survey method based on manpower and funding available. The Provincial ferruginous hawk coordinator accepted one survey method and several recommendations in consultation with Saunders and ferruginous hawk survey staff. These include:

1. Increase the number of surveys quadrats.
2. Stratify the quadrats into 2 strata (< 50% and ≥50% native prairie habitat) with 60% of surveys occurring in the ≥50% native prairie habitat or high strata.
3. Decrease the project area to the 1987-1992 areas.

The 2005 ferruginous hawk inventory was implemented based on these design recommendations.

3.0 METHODS

3.1 Project Area

The project area extends south from the town of Consort to the Canada/US border and west from the Saskatchewan border to Calgary and Pincher Creek (Figure 1). The area is approximately 77, 947 km^2. The natural subregions included in this study are the dry mixed-grass, mixed grass and parts of the northern fescue (Achuff 1994). The core population of ferruginous hawk is located within these regions of the Grassland Natural Region. There are small numbers of ferruginous hawks in the excluded areas but these numbers are negligible. Agriculture is the dominant land use with vast areas of cultivated fields, pasturelands and a few large tracts of native prairie scattered throughout the region. Oil and gas development, towns and cities are also present.

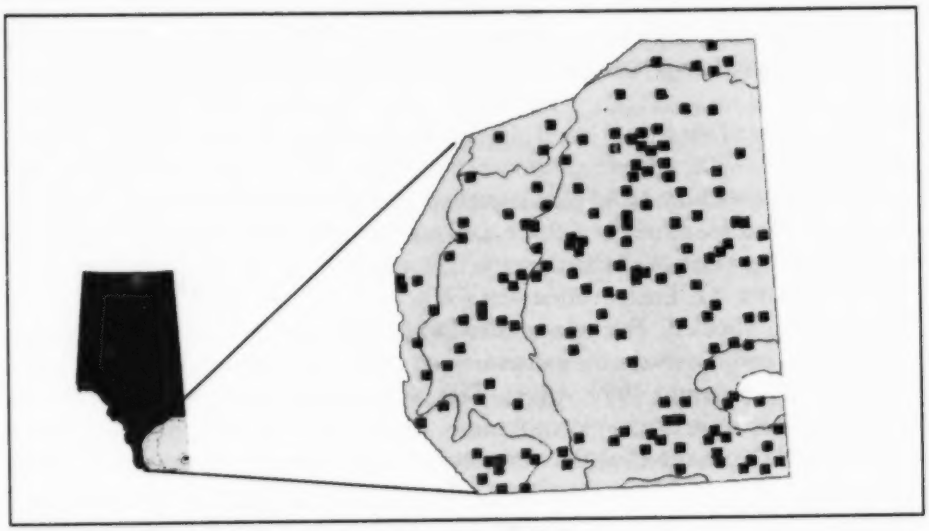

Figure 1: The ferruginous hawk project area and survey quadrats.

The Native Prairie Vegetation Inventory was used to divide the quadrats into 2 stratums, high and low, based on the amount of native prairie habitat available in each quarter section (Prairie Conservation Forum 2000). The high stratum included all areas that contain greater than or equal to 50% native prairie and accounts for approximately 40% of the project area. The low stratum included areas that were considered less than 50% native prairie.

3.2 Survey Quadrats

Both Taylor (2003) and Saunders (2005) recommended an increase in the number of ferruginous hawk sample quadrats. All 87 of the previously designed quadrats were included in the 2005 surveys and 63 new quadrats were added. The 17 quadrats added in the Foothills Fescue subregion in 2000 were not surveyed in 2005, as they were no longer included in the project area (Saunders 2005). The original 87 quadrats were allocated into the two strata (high and low) based on the Native Prairie Vegetation Inventory (Prairie Conservation Forum 2000). An additional 63 quadrats were randomly selected from the study area. In order to meet with Saunders recommendations to have 60% of the surveys occur in the high strata, only the first 7 randomly selected low strata quadrats were kept. This was due to the large number of original quadrats that were already in the low strata. A total of 150 quadrats were selected for the 2005 survey, 91 in the high strata and 59 in the low strata.

3.3 Observer Training

Quadrats were divided between Alberta Fish and Wildlife Division (AF&WD), Alberta Conservation Association (ACA), Dinosaur Provincial Park staff and AF&WD project staff. Permanent staff members rather than project staff completed the majority of the quadrats (111) while project staff completed 39. To ensure observer consistency the

project biologists provided, training sessions for all participants in Medicine Hat, Calgary, Red Deer, Edmonton and the Lethbridge. Training session included instructions on survey methodology, survey history, and species identification.

3.4 Survey Protocol

Surveys began on May 1 and continued to July 9, 2005. At the start of each survey weather conditions, number of observers, and start times were recorded. Surveys were not done during periods of rain or snow and when winds exceeded 6 on the Beaufort scale (Appendix A). Each quadrat was 6.4 km x 6.4 km in size with all roads within the quadrat being traveled. Ferruginous hawks are known to be highly susceptible to human disturbances and observers were discouraged from approaching potential nests sites unnecessarily (Schmutz 1999, Alberta Fish and Wildlife Division 2001). Binoculars and spotting scopes were used to identify nests away from roads or trails. In areas that were not accessible from vehicles, the observers used quads, bikes or walked to access the areas.

Raptors observed were recorded on the ferruginous hawk data sheet and plotted on the corresponding quadrat map. Locations of raptors were recorded using a Garmin GPS unit in Universal Transverse Mercator (UTM) in Nad 83. A list of species of interest was provided to the observers and if detected were recorded on the ferruginous hawk data sheet (Appendix B). Quadrat maps were updated to reflect structural and land use changes since the last survey period. Previous species points were removed from the map to avoid observer bias. Habitat maps were drawn for new quadrats during the survey.

Nest habitat data sheets were completed when a ferruginous hawk nest was found. For each nest site, the type of nesting structure, height of the nest, and percentage of various habitat types within an 800 m by 800 m area of the nest was recorded. The number of young in each nest was also recorded when they could be seen. Nests were considered active if new material had been added to the nest, a bird was present on the nest, or if young could be seen in the nest. At the completion of the survey the end time and weather conditions were recorded. All data was entered in the Biodiversity/Species Observation Database (BSOD).

3.4.1 Richardson's Ground Squirrel Surveys

A Richardson's ground squirrel monitoring inventory was designed in 2003 (Stepnisky et al. 2002 and Downey 2003). Surveys were completed using the playback alarm call method described by Downey (2003) on 48 of the 87 ferruginous hawk quadrats established between 1982-2000. The new 2005 ferruginous hawk quadrats and stratification process were not established at the time of selection. Due to this the Richardson's ground squirrel surveys were not selected based on strata, but through random sampling. Data from the ground squirrel survey and ferruginous hawk inventories will be analyzed during an on going study however a preliminary analysis is included in this report.

3.5 Data Analysis

In past survey years the population and 95% confidence intervals were developed using the calculations described by Schmutz (1982). In an effort to tighten the confidence limits the ferruginous quadrats were divided into 2 strata (high and low) and the numbers of active ferruginous hawk nests were counted in each stratum (Taylor 2003). Active nest sites were used to calculate the population. For the purpose of this study each active nest site represents one breeding pair or two ferruginous hawk adults. The population was estimated using Krebs (1989) method for stratified populations (Appendix C).

4.0 RESULTS

4.1 Population Estimate

A total of 147 quadrats were surveyed in 2005; 88 in the high strata and 59 in the low strata. Observers were not granted access to the Canadian Forces Base in Suffield and the Siksika nation. Four quadrats were selected to replaced these using the same random sample selection method. Two quadrats were not completed due to the extreme wet weather in June; and these quadrats were not replaced. During the survey 790 km^2, located at the extreme northern end of the study area was removed based on an observer assessment of the habitat. One quadrat was not included in the analysis due to this exclusion.

Within the completed quadrats, 47 ferruginous hawk nests were observed in the high strata and 11 in the low stratum. Based on the number of nests and the total areas surveyed in each stratum the ferruginous hawk population estimate is 618 +/- 162 breeding pairs. This is similar to the 2000 estimate and significantly lower than the 1992 and 1987 estimates (Table 2, Figure 2).

Table 2: The estimated number of ferruginous hawk pairs in Alberta, 1982-2005

Year	Number of Quadrats	Study Area (km^2)	Estimated Number of Pairs	95% Confidence Limit	95% Confidence Intervals
1982*	80	74,686	1082	40.5	653-1511
1987*	83	77,947	1791	28.5	1307-2275
1992*	85	77,947	1702	30.6	1181-2223
2000+	86	77,947	731	50.1	364-1097
2005	147	77,157	618	26.2	456-780

* Data from Schmutz 1993

+ Data From Stepnisky et al. 2002

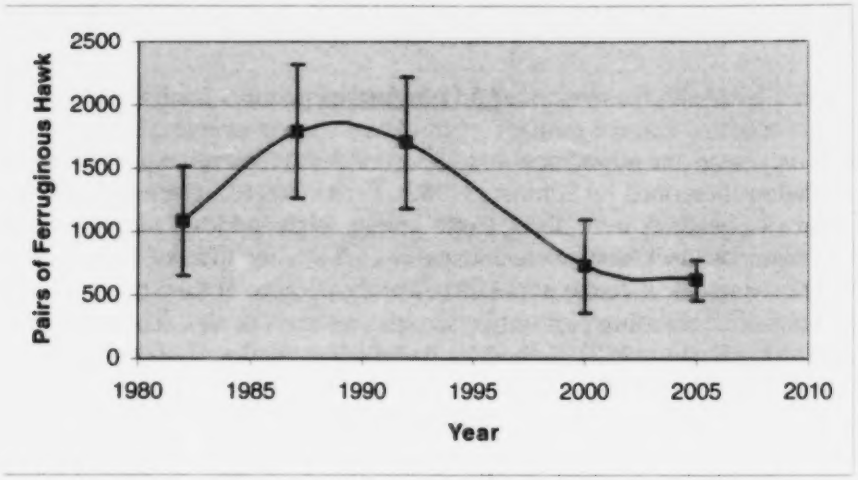

Figure 2: The estimated number of ferruginous hawk pairs and confidence intervals in Alberta between 1982-2005.

In order to assess the effectiveness of the new analysis, the population estimate was recalculated using Schmutz's original formulas (Schmutz 1982). This was done using only the original 81 quadrats that were survey in 2005 without stratification as well as for all 147 quadrats without stratification (Table 3). The resulting confidence limits using Schmutz formulas are much higher than the 2005 habitat stratified results. The stratified method used in 2005 yields the tightest confidence intervals and provides the best population estimate.

Table 3: Comparison of analysis and survey methods.

Method	Number of Quadrats	Estimated Number of Pairs in 2005	95% Confidence Limit	95% Confidence Intervals
Schmutz 1982/ simple random sample	81	736	45.1	404-1067
Schmutz 1982/ simple random sample	147	722	32.2	490-955
Krebs 1989/ stratified random sample	147	618	26.2	456-780

4.2 Population Trends

A sub sample of quadrats have been surveyed over the past 3 years to help discern trends within the ferruginous hawk population. Five quadrats were selected from each of the Alberta Fish and Wildlife Division resource management areas to be surveyed each year (Taylor 2003). A total of 30 quadrats were surveyed in 2000, 2003, 2004 and 2005 and these were compared using linear regression analysis (Cerney and Jones 2003). No significant difference in the number of nests/quadrat was observed between 2000-2005 ($t = -0.299$; $p = 0.767$). This suggests that the population was stable at low levels over the 2000-2005 monitoring period (Figure 3).

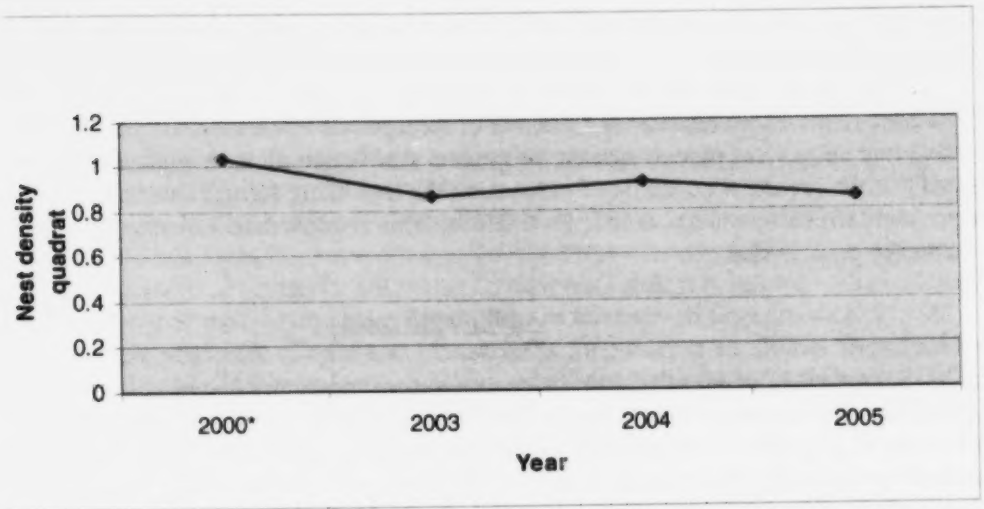

Figure 3: Density of ferruginous hawk nests on 30 quadrats monitored annually since 2003 and once every 5 years in 2000 and 2005.
* Data From Stepnisky et al. 2002

A similar trend study has been conducted in the Lethbridge region since 1997 on 25-34 quadrats. Unlike the quadrats that were randomly sampled from the entire study area, the majority of the quadrats (32) fall within the low habitat stratum. Therefore the data can not be used to represent the majority of the ferruginous hawk population and was not analyzed here.

4.3 Habitat Data

4.3.1 Richardson's Ground Squirrels

A total of 48 ground squirrel transects were completed in 2005, 23 in the high strata and 25 in the low strata. The quadrats were selected prior to the 2005 habitat stratification, hence the difference in allocation of transects between strata. The ground squirrel density was compared between low and high strata assuming variance was unequal using a t-test. The mean density of ferruginous hawk nests was also compared to the habitat strata assuming equal variance, using a t-test. The number of nests was significantly different between strata (t= 2.491; 0.016) however the number of ground squirrels did not differ significantly (t = 1.741; 0.091). This may be due to slight differences in habitat requirements for the two species.

4.3.2 Cultivation

Quadrats were stratified based on the amount of native prairie habitat available in each quadrat. This was done based on the hypothesis that ferruginous hawks would have higher densities where native prairie is more abundant (Schmutz 1982, 1987, 1993, and Stepnisky et al. 2002). Out of the 58 nests found in 2005, 12 were in low strata quadrats (high cultivation). The nest data was also compared to the habitat data collected within 800 meters of each nest site. Using this nest habitat data only 6 of the 58 nests were

found to be in areas of high cultivation. So, even though the nests were located in a "low" quadrat they were in the grassland portions of these quadrats.

To test the relationship between the number of ferruginous hawks and the amount of cultivation; nests were plotted against the percent cultivation on each quadrat. It was found that the greater the amount of cultivation the less likely ferruginous hawk nests were found (Spearman's r_s= -0.187, P= 0.0238). This is consistent with previous surveys (Stepnisky et al. 2002).

4.4 Additional Species

In 2005, a total 97 Swainson's hawk (*Buteo swainsoni*) nests and 30 red-tailed hawk (*Buteo jamaicensis*) nests were observed on quadrats during the ferruginous hawk inventory. A population estimate was completed for these species using Krebs (1989) method for a stratified population (Table 4). This resulted in a Swainson's hawk population estimate of 1408+/- 286 breeding pairs in the Grassland Natural Region of Alberta. A population estimate was not completed for the species in 2000 but an estimate was calculated from the 2000 surveys dataset in 2005. This resulted in a 2000 estimate of 1516+/- 348. Both the 2000 and 2005 estimates are significantly less than the population estimate of 6405 +/- 1252, completed in 1992 (Schmutz 1993).

Table 4: Population estimates for the Swainson's hawk and red-tailed hawk.

Species	Population Estimate	95% Confidence Limit	95% Confidence intervals
Swainson's Hawk	1408	20.3	1121-1695
Red-tailed Hawk	472	36.1	301-643

The red-tailed hawk has very different habitat requirements than the ferruginous hawk, and is normally only found in wooded areas within the Grassland Natural Region (Schmutz 1993). Therefore the habitat sampled and search methods employed during the course of the survey may not have been the most suitable for the red-tailed hawk. Due to this the population estimate of 472 +/- 170 breeding pairs is not considered representive of the red-tailed hawk population in the Grassland Natural Region and does not reflect population in other areas of the province.

In addition to the two hawk species several other incidental species were detected during the 2005 ferruginous hawk inventory (Appendix D). These include two burrowing owl (*Athene cunicularia*) nests, 27 loggerhead shrikes (*Lanius ludovicianus*), 63 Sprague's pipits (*Anthus spragueii*), 4 short-eared owls (*Asio flammeus*), and 99 long-billed curlews (*Numenius americanus*). There was no analysis conducted for these species but the observations were submitted to BSOD.

5.0 DISCUSSION

The 2005 survey estimate indicates a significant population decline over the last 13 years. The current estimate of 618 +/- 162 breeding pairs is the lowest population to date and is less then half of the 1992 estimate. The changes in the 2005 survey and analysis methods increased confidence in the survey results and population estimate. The resulting

confidence intervals were found to be 45% tighter when using a habitat stratified method combined with an increased number of quadrats than the methods used in previous years. This reduces the chances of the one population estimate overlapping with previously populations. Trend data collected between 2000-2005 indicates that the population has been at a low level since at least 2000.

The 2005 inventory was based on a project area that included 93% of the Grassland Natural Region, the area known to contain the majority of the provincial population of ferruginous hawks. It should be noted that ferruginous hawks are known to occur outside this area, however past surveys have shown that the numbers of ferruginous hawks in these areas are negligible (Taylor and Iwassa 2000, Stepnisky et al. 2002). Therefore the population may be slightly higher than calculated. The Alberta ferruginous hawk coordinator estimates that approximately 50 pairs reside in outlying areas (Quinlan pers.comm.).

Based on the confidence intervals and trend data, the 2005 population estimate is considered reliable for status and management decisions. The 2005 data shows that the ferruginous hawk population in Alberta has dramatically declined over the last decade. Based on these results the species should be reexamined by the Scientific Subcommittee of the Endangered Species Conservation Committee to confirm legislative status.

Two other hawks were inventoried during the 2005 survey period, the Swainson's hawk and the red-tailed hawk. Population estimates for both species were completed using Krebs (1989) method for a stratified population. However the estimates provided here does not take into account the different habitat requirements of the Swainson's hawk and red-tailed hawk from the ferruginous hawk. Both species are typically found in well treed or shrubby areas whereas the ferruginous hawk is found in areas of open native grassland (Schmutz 1993). Schmutz (1993) noted the majority of Swainson's hawks and red-tailed hawks were found in the northern sections of the study area or prairie-parkland interface. The survey quadrats were selected based on the habitat requirements of the ferruginous hawk and due to this the majority of surveys were conducted in areas of wide-open native prairie habitat and very few surveys were conducted in the northern region of the study area. Therefore the population estimates included here may not fully represent the other two species populations. It should be noted that the Swainson's hawk population is substantially lower than the last estimate (Schmutz 1993) and monitoring may be required in appropriate areas to determine if this is significant or not.

There are several environmental factors, which may have contributed to the decline in the ferruginous hawk population. These include: loss of grassland habitat, lack of nesting sites, disturbances from oil and gas development, interspecific competition, changes in prey populations and the effects of weather and climate changes. Two of these were examined in detail during this study; cultivation levels and changes in Richardson's ground squirrel (prey) populations.

Ferruginous hawks are dependent on native prairie habitat for nesting and hunting (Schmutz 1982, 1987, 1993, Stepnisky et al. 2002). The effect of cultivation on the

number of ferruginous hawks has been examined several times with similar results; the greater the amount of cultivation the less likely ferruginous hawks will select the area. Similar trends have been observed in Saskatchewan, Manitoba, Utah and North Dakota (Gilmer and Stewart 1983, Woffinden and Murphy 1989, Schmutz 1993, 1994). Avoidance of these areas may be due to the increase amount of disturbance in and around potential nest sites. Studies have shown ferruginous hawks are easily flushed and have a high potential to abandon nest sites when disturbed by humans early in the nesting season (Howard and Wolfe 1976, Gilmer and Stewart 1993). The increased disturbance in cultivated areas caused by human activities may cause nest failure, relocation, or avoidance by ferruginous hawks. However, the amount of cultivation has not significantly increased between 1982 and 2005 on the 81 original quadrats that were surveyed. Though it has not increased, farming activity still influences other habitat features of the ferruginous hawk. This suggests the amount of cultivation is probably not the primary factor in the recent population decline, but levels of cultivation should continue to be monitored throughout the study area.

The significance of the relationship between ground squirrels and ferruginous hawks has been examined several times over the past 25 years. The 2005 results did not show a strong relationship between ground squirrels and areas of $\geq$ 50% native prairie habitat, which was highly suitable for the ferruginous hawk. However the ground squirrel has been shown to use native prairie more than expected and cultivation less than expected in Alberta when the study area is broken into smaller stratums (Downey et al. 2006). Though the divisions between low and high habitat stratums vary slightly between the two species the Richardson's ground squirrel remains a key part of the ferruginous hawks habitat requirements. The significance of this relationship as well as other key habitat features are currently being tested and results should be available in 2006 (Downey pers. comm.).

To date the majority of habitat variables have been measured at the quadrat level or macro site scale. Data on nesting structures, human disturbances and vegetation cover within an 800 m x 800 m area was also collected at each nest site in an effort to examine micro site habitat influences. However, there is not enough data yet to conduct trend analysis on key features. The nest data should continue to be tracked during the annual surveys and in the 2010 population survey for all species of hawks on the quadrat. This information may be used to determine the amount of cultivation tolerated by the species, nest site fidelity, and other disturbances that directly effect nest site selection.

In 2002 several factors were identified which may have contributed to the decline in the number of ferruginous hawks (Stepnisky et al. 2002). Oil and gas development, climate change, wind farms and wintering habitat alterations may negatively affect the ferruginous hawk population. However there has been no research to quantify the effects of these factors on the ferruginous hawk. This would require intensive monitoring on several sites, which was well beyond the scope of this project. A study identifying major breeding and over wintering habitat has been initiated (Ferruginous hawk.org 2005). Research on the effects of oil and gas development as well as climate change is required

to determine if these factors contributed to the recent decline in the ferruginous hawk population.

The ferruginous hawk population has significantly declined since the early nineties and like several other species the exact cause of this decline is unknown. The current population is probably a result of several contributing factors including, but not limited to: increased human disturbance, decreased prey abundance, loss of habitat, interspecific competition and climate change. In order to manage the species for the future a balance between these factors and the ferruginous hawk must be found.

6.0 RECOMMENDATIONS

In order to manage and monitor the ferruginous hawk the following initiatives should be carried out:

1. The Scientific Subcommittee of Endangered Species Conservation Committee (ESCC) should review the results of the 2005 survey.

There has been a decline in the number of ferruginous hawk pairs in the province of Alberta. The new information provided by the 2005 survey should be reviewed by the SSC to review Alberta's Wildlife Act designation of "Threatened" for the ferruginous hawk.

2. A full survey should be completed every 5 years.

Continued monitoring is necessary to understand the population trends and the effects of management initiatives. The next provincial inventory should be conducted in 2010.

3. The survey quadrats should be restratified based on the amount of native prairie habitat when the Grassland Vegetation Index is completed.

The Native Prairie Vegetation Inventory (NPVI) was used to stratify the survey quadrats. However the NPVI is a coarse model that defines habitat at the quarter section level and has resulted in some discrepancies between predicted habitat values and observed values. The Grassland Vegetation Index (GVI) that is currently being developed will examine habitat at a finer scale than the NPVI. When the GVI is completed it should be used to reassess the stratification of all 150 quadrats to reconfirm which strata each quadrat is allocated to.

4. A sub sample of quadrats should be surveyed annually.

Annual monitoring of a sub sample of quadrats allows insight into the population dynamics between the 5-year studies (Taylor 2003). This can also be used to identify environmental factors, which may have altered population trends such as weather phenomena, change in prey densities, and nest site availability.

5. Richardson's ground squirrel populations should continue to be monitored in conjunction with the ferruginous hawk surveys.

The current survey method for ground squirrels should be continued in conjunction with the ferruginous hawk annual monitoring surveys and the 2010 population survey. This will allow further insight into this important relationship and allow better management decisions for the ferruginous hawk. However in order to sustain the project surveys for the Richardson's ground squirrel should only be conducted along the 30 annual monitoring ferruginous hawk quadrats.

6. Future research should concentrate on habitat features and land uses with suspected negative or positive influence on the ferruginous hawks.

The effects of many habitat features are unknown. Future research should concentrate on the effects of oil and gas development, nest site availability and nest site habitat, which may influence the ferruginous hawks. This information is critical to understanding the habitat requirements and the effects of human disturbance on the species.

7. Review and revise wind energy guidelines.

Though wind energy is a clean source of power, the creation of wind farms can negatively impact wildlife. Wind turbines can cause direct mortalities and nest abandonment for species such as ferruginous hawk and Swainson's hawk. Based on preliminary information from Alberta wind farms, Swainson's hawks appear to be particularly vulnerable to collision-related mortalities (Quinlan per.comm.). Guidelines have recently been developed addressing setbacks and timing of these wind farms. These guidelines should be reviewed and revised as new information comes available.

8. Initiate a Ferruginous Hawk Recovery Team to develop a recovery plan.

During the winter of 2005-2006 a provincial recovery team should be initiated to prepare a provincial recovery plan for the ferruginous hawk.

9. Swainson's hawks should be monitored to determine the species status in Alberta.

The Swainson's hawk is currently considered "Sensitive" in Alberta (The General Status of Alberta Wild Species 2001). The population estimate for the species determined during the 2005 Ferruginous hawk inventory indicates a substantial decline in the number of nesting pairs in the province. The survey method and the sample areas used in 2005 may not adequately reflect the Swainson's hawk population but the downward trend indicated since 1992 is reason for concern. There needs to be more emphasizes on the monitoring of the Swainson's hawk population in the future and a review or the provincial status should be considered.

10. Within the Grassland Natural Region the ferruginous hawk should be identified as a primary management species.

Within the Grassland Natural Region of Alberta the ferruginous hawk should be identified as a primary management species by government and conservation agencies. It is important that the habitat requirements of this species be incorporated into habitat conservation strategies of conservation organizations such as Operation Grassland Community, Alberta Conservation Association, Nature Conservancy of Canada, Duck Unlimited Canada and others.

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8.0 PERSONAL COMMUNICATION

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Appendix A

Beaufort Wind Scale

Force	Wind Speed			WMO Description	Wind Speed Indicators	
	MPH	Knots	KPH		At Sea	On Land
0	<1	<1	<1	Calm	Smooth as glass	Calm; smoke rises vertically
1	1-3	1-3	1-5	Light Air	Ripples with appearance of scales; no foam crests	Smoke drift indicates wind direction; vanes do not move
2	4-7	4-6	6-11	Light Breeze	Small wavelets; crests of glassy appearance	Wind felt on face; leaves rustle; vanes begin to move
3	8-12	7-10	12-19	Gentle Breeze	Large wavelets; crests begin to break, scattered whitecaps	Leaves & small twigs in motion; light flags extended
4	13-18	11-16	20-29	Moderate Breeze	1-4 ft. waves; numerous whitecaps	Leaves, & loose paper raised up; flags flap; small branches move.
5	19-24	17-21	30-38	Fresh Breeze	4-8 ft waves; many whitecaps; some spray	Small trees begin to sway; flags flap & ripple
6	25-31	22-27	39-50	Strong Breeze	8-13 ft waves forming white caps everywhere; more spray	Large branches in motion; whistling heard in wires
7	32-38	28-33	51-61	Near Gale	13-20 ft. waves; white foam blows in streaks	Whole trees in motion; resistance felt in walking against wind
8	39-46	34-40	62-74	Gale	13-20 ft. waves; edges of crests begin to break; foam in streaks	Whole trees in motion; resistance felt in walking against wind
9	47-54	41-47	75-86	Strong Gale	20 ft. waves; sea begins to roll; dense streaks of foam	Slight structural damage occurs; shingles blow from roofs
10	55-63	48-55	87-101	Storm	20-30 ft. waves; white churning sea; rolling is heavy; reduced visibility	Trees broken or uprooted; considerable structural damage occurs
11	64-74	56-63	102-120	Violent Storm	30-45 ft. waves; white foam patches	Widespread damage to trees & buildings
12	75+	64+	120+	Hurricane	45 ft.+ waves; white sea; driving spray	Severe & extensive damage

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Appendix B

ADDITIONAL SPECIES TO RECORD

Common / Latin names	Data Sheet Code
American Badger / *Taxidea taxus*	BADG
Baird's Sparrow / *Ammodramus bairdii*	BDSP
Bobcat/*Lynx rufus*	BOBC
Bobolink / *Dolichonyx oryzivorus*	BOBO
Bullsnake / *Pituophis catenifer*	BULL
Burrowing Owl / *Athene cunicularia*	BUOW
Golden Eagle / *Aquila chrysaetos*	GOEA
Great Blue Heron / *Ardea herodias*	GBLH
Loggerhead Shrike / *Lanius ludovicianus*	LOSH
Long-Billed Curlew / *Numenius americanus*	LBCU
Long Tailed Weasel / *Mustela frenata*	LTWE
Mountain Plover / *Charadrius montanus*	MTPL
Peregrine Falcon / *Falco peregrinus*	PEFA
Piping Plover/*Charadrius melodus*	PIPL
Prairie Falcon / *Falco mexicanus*	PRFA
Prairie Rattlesnake / *Crotalus viridis*	PRRA
Pronghorn / *Antilocapra americana*	PRON
Red-tailed Hawk / *Buteo jamaicensis*	RTHA
Sage Grouse / *Centrocercus urophasianus*	SAGR
Sage Thrasher / *Oreoscoptes montanus*	SATH
Sandhill Crane / *Grus canadensis*	SACR
Sharp-tailed Grouse / *Tympanuchus phasianellus*	STGR
Short-eared Owl / *Asio flammeus*	SEOW
Sprague's Pipit / *Anthus spragueii*	SPPI
Swainson's Hawk / *Buteo swainsoni*	SWHA
Swift Fox / *Vulpes velox*	SWFO
Thirteen-lined Ground Squirrel / *Spermophilus tridecemlineatus*	TLGS
Trumpeter Swan / *Cygnus buccinator*	TPSW
Upland Sandpiper / *Bartramia longicauda*	UPSA

Appendix C

Stratified Random Sampling (Krebs 1989)

The following formulas were used to calculate the population estimate of ferruginous hawk, Swainson's hawk and red-tailed hawks in Alberta. For full explanation please refer to Krebs, 1989 method for a stratified population estimate.

A) Population total: sum of the population estimate for each stratum.

$$X_{st}=Nx_{st}$$

X_{st}- Population Total
N- Number of sample units in the entire population
x_{st}- Stratified mean/ sampling unit

B) The overall mean/sampling unit for the population: the mean number of individuals observed /stratum.

$$x_{st} = \frac{\sum_{h=1}^{l} N_h x_h}{N}$$

x_{st} – Stratified population mean/sampling unit
N_h- Size of stratum h
h- Stratum number
x_h- Observed mean for stratum h
N- Total population size $=\sum N_h$

C) Stratum Weight: percent of total area in each stratum.

$$W_h = \frac{N_h}{N}$$

N_h = Size of stratum h
N- Size of entire statistical population

D) Variance of a stratified mean: variance of the mean number of individuals/ stratum

$$\left[\text{Var}\,(x_{st}) = \sum \frac{(w_h^2 s_h^2\,(1-f_h)}{n_h} \right]$$

w_h- Stratum weight
s^2_h- observed variance of stratum
n_h- Sample size of stratum h
f_h- sampling fraction in stratum h= n_h/N_h

E) Variance of the Population Mean: variance of the entire population.

Variance of the Population Mean $(X_{st}) = (N)^2$(variance of x_{st})

F) Standard Error: required to determine the confidence limits

Standard Error of $(x_{st}) = \sqrt{\text{variance of } x_{st}}$

G) Effective Degrees of Freedom- required to determine the value of t (95% CI).

$$Df = \frac{(\sum_{h=1}^{l} g_h s^2_h)^2}{\sum_{h=1}^{l} (g^2_h s^2_h)/(n_h - 1))}$$

g_h- $N_h(N_h - n_h)/n_h$
s^2_h- Observed variance in stratum h
n_h- Sample size in stratum h
N_h- Size of stratum h

H) Confidence limits

X_{st} +/-Standard Error of $(x_{st}) = \sqrt{\text{variance of } x_{st}}$

Appendix D

Incidental Species Detected During the 2005 Ferruginous Hawk Inventory

Species	Nests/Den	Adults	Young
American Badger	0	5	0
American Bittern	0	2	0
American Kestrel	0	2	0
American White Pelican	0	21	0
Black-bellied Plover	0	10	0
Black-crowned Night Heron	0	1	0
Baird's Sparrow	0	8	0
Bullsnake	0	1	0
Burrowing Owl	3	3	0
Canada Goose	2	3	0
Great-horned owl	5	12	7
Golden Eagle	2	6	1
Gray Partridge	1	24	0
Long-billed Curlew	0	99	0
Lark Bunting	0	2	0
Loggerhead Shrike	2	27	0
Marbled Godwit	0	7	0
Merlin	1	4	0
Northern Leopard Frog	0	1	0
Northern Harrier	0	65	0
Pronghorn	0	46	3
Raven	1	1	0
Ring-necked Pheasant	0	2	0
Red-tailed Hawk	30	88	5
Short-eared Owl	0	4	0
Sprague's Pipit	0	63	0
Sharp-tailed Grouse	0	5	0
Swainson's Hawk	97	265	0
Upland Sandpiper	0	16	0

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